Mattoon Lake

Integrated Aquatic Vegetation
Management Plan

Kittitas County
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April 2007

Executive Summary

Eurasian watermilfoil (*Myriophyllum spicatum*) is a submersed aquatic noxious weed that proliferates to form dense mats of vegetation in the littoral zone of lakes and reservoirs. It reproduces by fragmentation, and is often spread as fragments that "hitch-hike" on boat trailers from one lake to another. Eurasian watermilfoil (milfoil) can degrade the ecological integrity of a water body in just a few growing seasons. Dense stands of milfoil crowd out native aquatic vegetation, which in turn alters predator-prey relationships among fish and other aquatic animals. Milfoil can also reduce dissolved oxygen – first by inhibiting water mixing in areas where it grows, and then as oxygen is consumed by bacteria during decomposition of dead plant material. Decomposition of milfoil also adds nutrients to the water that could contribute to increased algal growth and related water quality problems. Further, dense mats of milfoil can increase the water temperature by absorbing sunlight, create mosquito breeding areas, and negatively affect recreational activities such as swimming, fishing, and boating.

Mattoon Lake, just outside the city limits of Ellensburg, Washington, is owned by the Washington Department of Fish & Wildlife (WDFW) and is a popular attraction for both local and visiting recreationalists. It has become moderately to heavily infested with Eurasian watermilfoil and, due to lack of funding and time available, WDFW has not been able to address the problem. Members of the Kittitas County Field & Stream Club have voiced concerns over the potential gravity of the aquatic weed problem and initiated a partnership with staff from WDFW and the Kittitas County Noxious Weed Control Board (KCNWCB) to pursue grant monies, such as the Aquatic Weeds Management Fund through the Washington State Department of Ecology, in an effort to address the problem and implement a control strategy. Since complete eradication is very difficult to achieve, and re-introduction is likely, the involved community is organizing a management structure and the funding mechanisms necessary to implement ongoing monitoring and spot control.

Three other noxious weed species have the potential to degrade the ecological and recreational benefits of the lake as well. Yellow flag iris (*Iris pseudacorus*) is already well established around the shoreline and purple loosestrife (*Lythrum salicaria*) continues to be introduced in isolated occurrences and preventing its establishment is a high priority. Curly leaf pondweed (*Potamogeton crispus*) is also found in the lake at moderate densities.

This *Integrated Aquatic Vegetation Management Plan* (IAVMP) is a planning document developed to ensure that the applicant and the involved community have considered the best available information about the waterbody prior to initiating control efforts. WDFW staff, members of the Kittitas County Field & Stream Club, and KCNWCB staff worked in partnership to develop this IAVMP for Mattoon Lake. Those involved are in agreement that an integrated treatment strategy, which includes initial chemical treatments with a systemic aquatic herbicide followed by a maintenance plan utilizing

chemical, mechanical, and possibly biological control methods, is the most appropriate and beneficial plan to be implemented.
This plan presents Mattoon Lake characteristics, details of the aquatic weed problems at the lake, the process for gaining community involvement, discussion of control alternatives, and recommendations for initial and ongoing control of noxious aquatic weeds threatening Mattoon Lake.

Problem Statement

In the summer of 2001 during a routine Department of Ecology aquatic plant survey of Mattoon Lake, the presence of Eurasian watermilfoil was first officially noted. This noxious, non-native invasive species has been spreading at a steady rate and has rapidly filled in the shoreline out to a depth of about ten feet. In the last six years, milfoil has heavily infested the west end of the lake, and plants are well established along the perimeter of the rest of the lake. Recreational activities such as fishing and boating have been affected due to the density of the plant colonies including the area around the single dock and boat ramp that is maintained by WDFW.

The committee is concerned that Eurasian watermilfoil is altering the ecological balance of the lake, affecting fish and wildlife habitat and the popular year-round fishery that presently exists at the lake.

Another important concern of the committee is the potential for the spread of Eurasian watermilfoil to other lakes in the surrounding area. This noxious weed is known to establish new infestations from plant fragments and is easily transported to other locations on boat motors, trailers, and fishing gear. There are several lakes and streams in the area, including the Yakima River, that currently are not infested with milfoil.

If left untreated Eurasian watermilfoil will continue to blanket a majority of the lake, preventing most recreational uses and eliminating wildlife habitat. There will be long-term financial and recreational loss and the loss of conservation areas, all affecting recreationalists and other members of the public who use the lake. Dense milfoil growth significantly degrades fishing opportunity, and the portion of the lake where people can fish is steadily shrinking.
A summary of the current or potential issues regarding Eurasian watermilfoil at Mattoon Lake include:

- Class B-Designate noxious weed in Kittitas County required for control by RCW 17.10
- A significant reduction in fish and wildlife habitat, thereby weakening the local ecosystem as well as degrading wildlife and wildlife viewing opportunities
- Crowding out native plants, creating monocultures lacking in biodiversity
- Posing a threat to adjoining ecosystems
- Posing a safety hazard to fisherman, swimmers, and boaters by entanglement
- Degrading shoreline fishing opportunity due to fishing gear entanglement

Mattoon Lake will soon become heavily infested with milfoil throughout the entire lake, severely degrading the lake ecosystem and making it even harder to eradicate. The committee recognizes that after initial control efforts, opportunity for re-infestation must be prevented.

The presence of three other aquatic noxious weeds also have the potential of threatening the fish and wildlife habitat at Mattoon Lake: purple loosestrife, yellow flag iris, and curly leaf pondweed.

Purple loosestrife is considered one of the worst noxious weed invaders of wetland habitat and its impact on various regions of Washington State has been significant. Fortunately, its current presence in Kittitas County is very limited and the Kittitas County Noxious Weed Control Board (KCNWCB) has taken great efforts to control all known sites as well as swiftly eradicating new introductions. Purple loosestrife was first discovered at Mattoon Lake by KCNWCB staff in 2001 when three mature plants were found on the east end of the lake in a seasonally marshy area between Mattoon Lake and Wilson Creek. These plants were quickly eradicated, however, since then at least one (at most five) have been discovered and controlled by KCNWCB staff every year since. In 2006, two plants were discovered and removed on the south shoreline. The steering committee agrees that purple loosestrife would have a detrimental impact on Mattoon Lake if it were allowed to establish. KCNWCB staff have stated that they will continue their surveys for purple loosestrife throughout Kittitas County, including Mattoon Lake, and have emphasized that control efforts will be implemented swiftly whenever it is discovered to prevent establishment.

Yellow flag iris has become the dominant species around the entire shoreline of Mattoon Lake and the steering committee agrees, that although it isn’t viewed as the most significant issue concerning the lake, it definitely needs to be addressed.

The presence of curly leaf pondweed in low - moderate densities at Mattoon Lake should also be recognized, however, the committee agrees that it rarely is a problem weed in Washington State and unless a dramatic increase in its presence on Mattoon Lake occurs, no control strategies need to be implemented. Monitoring of its density and distribution will continue indefinitely.

Aquatic Plant Management Goals

A set of goals have been developed for the Mattoon Lake Integrated Aquatic Plant Management Plan. These goals were formulated after discussion which took into account the lake and its characteristics, the Mattoon Lake area community, and all associated costs. The goals are outlined as follows:

- Reduce and then maintain Eurasian watermilfoil at as low a density as is environmentally and economically feasible with eradication as the ultimate goal.
- Control yellow flag iris along the lake shoreline.
- Eradicate purple loosestrife from the Mattoon Lake area and prevent reinfestation.

- Continue to monitor curly leaf pondweed densities.
- Seek a balanced approach for treatments. Take into consideration all beneficial uses including the recreational use, the fishery, and wildlife habitat.
- Develop and begin implementation of an educational plan that will reduce the chances of Eurasian watermilfoil spreading to other lakes and reintroduction.
- Develop and begin implementation of an aquatic survey of all lake vegetation.
- Seek funding mechanisms in order to fund control of invasive aquatic plants.

Lake Characteristics

Mattoon Lake is located near the town of Ellensburg in Kittitas County (T17N R18E sec 11). This 26 acre lake is relatively shallow, with a maximum depth of about four meters (Table 1). It is a former gravel pit created when I-90 was constructed and is now owned entirely by the Washington Department of Fish and Wildlife (WDFW). The lake is managed primarily as a put-and-take trout fishery that is open year-round. Both rainbow trout *Oncorhynchus mykiss* and brown trout *Salmo trutta* are stocked periodically. Surveys have shown that the lake also contains additional warm water and non-game species including largemouth bass *Micropterus salmoides*, pumpkinseed sunfish *Lepomis gibbosus*, and northern pikeminnow *Ptychocheilus oregonensis* (Eric Anderson, WDFW District Fish Biologist). Recreational access at Mattoon Lake is available to the public. A boat launch and dock are located on the west side of the lake. The north shoreline offers good access to shore anglers. Aquatic plants grow throughout the lake, but the dominant submersed plant in water 2-12 feet deep is Eurasian watermilfoil, *Myriophyllum spicatum*, which forms a surfacing mat that rings the lake. Other notable submersed species present include: *Elodea nuttallii* (Nuttall's waterweed), *Ceratophyllum demersum* (coontail), *Potamogeton pectinatus* (sago pondweed), *M. sibiricum* (northern watermilfoil), *Chara* sp (muskgrass), and the non-native *Potamogeton crispus* (curly leaf pondweed), which can be found at moderate densities. The shoreline is dominated by the non-native *Iris pseudacorus* (yellow flag iris) (Jennifer Parsons, Washington Department of Ecology Aquatic Plant Specialist).

Table 1. Physical parameters of Mattoon Lake (Kittitas County).

Physical Parameters	Mattoon Lake (Kittitas County)
Surface Area (acres)	26
Maximum Depth (meters)	4
Mean Depth (meters)	3

Fish and Wildlife Communities

Mattoon Lake and its surrounding habitats support a variety of fish, birds, and animals by providing nesting, forage, and cover. According to Washington Department of Fish and Wildlife (WDFW) the resident fish species in Mattoon Lake include rainbow trout (*Oncorhynchus mykiss)*, brown trout *Salmo trutta*, largemouth bass (*Micropterus salmoides)*, pumpkinseed sunfish (*Lepomis gibbosus)*, and northern pikeminnow (*Ptychocheilus oregonensis*). Mattoon Lake is on an annual stocking plan and, on average, receives about 12,000 rainbow trout and 2000 brown trout. Mattoon Lake is open all year to recreational angling and according to residents and WDFW, usually hosts several anglers per day between late March through October. However, most of the visits occur in early spring when the lake is stocked. Mattoon Lake falls under the General Statewide Regulations for limits and size restrictions set by WDFW.

Beneficial and Recreational Uses

Mattoon Lake and its surroundings support a variety of recreational activities to humans. These include fishing, boating (no combustion motors), bird watching, and wildlife viewing. A public boat launch maintained by Washington Department of Fish & Wildlife allows everybody to benefit from this beautiful resource as well.
No internal combustion engines are allowed on the lake, consequently there are no activities such as water skiing or jet skiing.

Noxious Aquatic Weeds in Mattoon Lake

There are currently four noxious aquatic weeds known to be present in Mattoon Lake: Eurasian watermilfoil (*Myriophyllum spicatum),* purple loosestrife (*Lythrum salicaria),* yellow flag iris (*Iris pseudacorus)*, and curly leaf pondweed (*Potamogeton crispus*). These species will be the focus of the plant management efforts on Mattoon Lake, with priority given to management of Eurasian watermilfoil . The term “noxious weed” refers to those non-native plants that are legally defined by Washington’s Noxious Weed Control Law (RCW 17.10) as highly destructive, competitive, or difficult to control once established. Noxious weeds have usually been introduced accidentally as a contaminant, or as ornamentals. Non-native plants often do not have natural predators (i.e. insects, pathogens) or strong competitors to control their numbers as they may have had in their home range. WAC 16.750 sets out three classes (A, B, C) of noxious weeds based on their distribution in the state, each class having different control requirements. County Weed Boards are given some discretion as to setting control priorities for Class B and C weeds. Eurasian watermilfoil and purple loosestrife are both Class B noxious weeds designated for control in Kittitas County by the Washington State Noxious Weed Control Board. Yellow flag iris is a Class C noxious weed listed for control in Kittitas County by the Kittitas County Noxious Weed Control Board. Culry leaf pondweed is not currently listed on the Kittitas County Noxious Weed List, however, it is a Class C noxious weed in Washington State.

Eurasian watermilfoil (*Myriophyllum spicatum*)

Eurasian watermilfoil is native to Europe, Asia, and North Africa and also occurs in Greenland (Washington State Noxious Weed Control Board, 1995). The oldest record of

Eurasian watermilfoil in Washington is from a 1965 herbarium specimen collected from Lake Meridian, King County. It was first identified causing problems in the 1970s in Lake Washington and proceeded to move down the I-5 corridor, probably transported to new lakes on boats and trailers. Eurasian watermilfoil is among the worst aquatic pests in North America. *M. spicatum* is a submersed, perennial aquatic plant with feather-like leaves. It usually has 12 to 16 leaflets (usually more than 14) on each leaf arranged in whorls of 4 around the stem. Leaves near the surface may be reddish or brown. Sometimes there are emergent flower stalks during the summers that have tiny emergent leaves. In western Washington, Eurasian watermilfoil frequently over-winters in an evergreen form and may maintain considerable winter biomass (K. Hamel, pers. comm.). This plant forms dense mats of vegetation just below the water's surface. In the late summer and fall, the plants break into fragments with attached roots that float with the currents, infesting new areas. Disturbed plants will also fragment at other times of the year. A new plant can start from a tiny piece of a milfoil plant. *M. spicatum* was not previously thought to reproduce from seed in this region. However, aquatic plant experts are beginning to think that milfoil seeds might be playing a bigger role in repopulating lakes than was previously hoped. Milfoil starts spring growth earlier than native aquatic plants, and thereby gets a "head start" on other plants. Eurasian watermilfoil can degrade the ecological integrity of a water body in just a few growing seasons. Dense stands of milfoil crowd out native aquatic vegetation, which in turn alters predator-prey relationships among fish and other aquatic animals. Eurasian watermilfoil can also reduce dissolved oxygen – first by inhibiting water mixing in areas where it grows, and then as oxygen is consumed by bacteria during decomposition of dead plant material. Decomposition of *M. spicatum* also releases phosphorus and nitrogen to the water that could increase algal growth. Further, dense mats of Eurasian watermilfoil can increase water temperature by absorbing sunlight, raise the pH, and create stagnant water mosquito breeding areas. Eurasian watermilfoil will negatively affect recreational activities such as swimming, fishing, and boating. The dense beds of vegetation make swimming dangerous, snag fish hooks on every cast, and inhibit boating by entangling propellers or paddles and slowing the movement of boats across the water.

At Mattoon Lake, *M. spicatum* is generally moderate to heavy in density. The infestation is established throughout most of the littoral zone with a few high-density milfoil stands. According to frequency data collected on Mattoon Lake between 2002 and 2005, milfoil on average was in 69% of the 115-120 random samples taken yearly (Jennifer Parsons, Washington Department of Ecology Aquatic Plant Specialist). In all likelihood, milfoil in Mattoon Lake has already reached is maximum density and will continue to degrade the habitat of the lake until the problem is seriously addressed.

Yellow flag iris (*Iris pseudacorus*)

Yellow flag iris is native to mainland Europe, the British Isles, and the Mediterranean region of North Africa (Washington State Noxious Weed Control Board, 2001a). This plant was introduced widely as a garden ornamental. It has also been used for erosion control. The earliest collection in Washington is from Lake McMurray in Skagit County in 1948 (Washington State Noxious Weed Control Board, 2001a). The yellow flowers are a distinguishing characteristic, but when not flowering it may be confused with cattail

(*Typha sp.*) or broad-fruited bur-reed (*Sparganium eurycarpum*). Yellow flag iris is considered an obligate wetland species (OBL), with a 99% probability of occurring in wetlands as opposed to upland areas (Reed, 1988). The plants produce large fruit capsules and corky seeds in the late summer. Yellow flag iris spreads by rhizomes and seeds. Up to several hundred flowering plants may be connected rhizomatously. Rhizome fragments can form new plants. Yellow flag iris can spread by rhizome growth to form dense stands that can exclude even the toughest of our native wetland species, such as *Typha latifolia* (cattail).

Yellow flag iris is fairly widespread in Kittitas County and can be found along the shoreline of many lakes and streams in the area. It is well-established and is the dominant species along most of the shoreline of Mattoon Lake.

Purple loosestrife (*Lythrum salicaria*)

Purple loosestrife is native to Europe and Asia and was introduced through ship ballast water to the Atlantic Coast in the mid-1800s (Washington State Noxious Weed Control Board, 1997). In Washington, purple loosestrife was first collected from the Seattle area in 1929 from Lake Washington. Purple loosestrife is a perennial that can reach 9 feet tall with long spikes of magenta flowers. The flowers usually have 6 petals, and the stems are squared-off. Purple loosestrife is considered a facultative wetland (+) species (FACW+), with a 67-99% probability of occurring in wetlands as opposed to upland areas (Reed, 1988). Vigorous plants can produce over 2 million tiny, lightweight seeds (120,000 per spike) that are easily spread by waterfowl and other animals (Washington State Noxious Weed Control Board, 1997). Although a prolific seeder, purple loosestrife can also spread through vegetative production by shoots and rhizomes as well as by root fragmentation. It has a woody taproot with a fibrous root system that forms a dense mat, keeping other plants from establishing in a space. Purple loosestrife disrupts wetland ecosystems by displacing native or beneficial plants and animals. Waterfowl, fur-bearing animals, and birds vacate wetland habitat when native vegetation is displaced by purple loosestrife. Loss of native vegetation results in decreased sources of food, nesting material, and shelter. Economic impacts are high in agricultural communities when irrigation systems are clogged or when wet pastures are unavailable for grazing. Purple loosestrife is aggressive and competitive, taking full advantage of disturbance to natural wetland vegetation caused by anthropogenic alterations of the landscape. Seed banks build for years since seeds may remain viable for up to 3 years. Monospecific stands are long-lived in North America as compared to European stands, illustrating the competitive edge loosestrife has over other plant species.

Purple loosestrife was first discovered at Mattoon Lake in 2001 when three mature plants were found (and controlled) on the east end of the lake in a seasonally marshy area between Mattoon Lake and Wilson Creek. In the years 2002 – 2006, at least one single plant has been discovered and controlled annually, with all but one located along the east end of the lake. Preventing establishment is critical and continued introduction is likely. KCNWCB staff will continue to survey for loosestrife and immediately control any plants discovered.

Curly leaf pondweed (*Potamogeton crispus)*
Curly pondweed is native to Eurasia and apparently was introduced into the United States in the mid 1800's (Stuckey 1979). Prior to 1900, the distribution of P. crispus was the northeastern United States. By 1930 curly leaf pondweed had spread westward to several states of the Great Lakes region. The species has since spread across much of the United States, presumably by migrating waterfowl, intentional planting for waterfowl and wildlife habitat, and possibly even as a contaminant in water used to transport fishes and fish eggs to hatcheries (Stuckey 1979). Curly leaf pondweed can form surface mats that interfere with aquatic recreation and dense colonies can restrict access to docks and sport fishing areas during spring and early summer months. Curly leaf pondweed has been noted as one of the most severe nuisance aquatic plants in the Midwest only out ranked by Eurasian Watermillfoil. Because populations of curly leaf pondweed usually decline during the summer months, it is seldom considered a problem plant in Washington.

Aquatic Control Alternatives for Eurasian Watermilfoil

This section outlines common methods used to control aquatic weeds. Much of the information in this section is quoted directly from the Ecology's website: http://www.ecy.wa.gov/programs/wq/plants/management/index.html

Eradication Strategy – 2,4-D treatment

2,4-D (aquatic herbicide):

2,4-D is a relatively fast-acting herbicide that kills the entire plant (systemic herbicide). Its mode of action is primarily as a stimulant of plant stem elongation. This herbicide is considered to be "selective" for milfoil because it generally targets the broad-leaved plants (dicots) like milfoil. Most other aquatic plants are monocots (grass-like) and are unaffected by 2,4-D. Using 2,4-D is an excellent way of selectively removing Eurasian watermilfoil while allowing native plants to flourish. Navigate® and Aqua-Kleen® are granular 2,4-D products (ester formulations) registered for aquatic use and DMA*4IVM® is a liquid formulation (amine formulation).

Waterbodies suitable for 2,4-D treatment:

Sites suitable for treatment include lakes or ponds partially infested with Eurasian watermilfoil such as water bodies where milfoil has recently invaded, but where the extent of the infestation is beyond what can be removed by hand pulling or bottom screening. In these situations an herbicide, like 2,4-D, that is effective for spot treatment can be used to reduce the amount of milfoil so that hand pulling can remove any milfoil plants that are not killed. 2,4-D is suitable for spot treatment because it is a fast-acting herbicide that only needs a 48-hour contact time with the plant.

The granular formulations of 2,4-D are less effective in killing all milfoil plants than the liquid formulation - 85-95 percent efficacy for the granular formulations versus up to 100 percent efficacy with the liquid formulation. Because some plants remain alive and scattered throughout the littoral zone after 2,4-D treatment with the granular product, hand pulling extensive areas after treatment may not be effective in heavily infested lakes. A reliable funding source, such as a Lake Management District or a committed local government, is necessary to fund the follow-up activities necessary to ensure continued milfoil eradication (or maintenance at extremely low amounts).

Special considerations:

Water users need to be identified prior to 2,4-D application. Water within the treatment areas cannot be used for drinking until 2,4-D concentrations have declined to 70 ppb and water used for irrigation cannot be used until 2,4-D concentrations are 100 ppb or less. If water users do not have other water sources, the project proponents must arrange for alternative water supply during the time that 2,4-D is in the water.

In Washington, testing has shown that water both inside and outside of the area treated with granular formulations is generally below the drinking water standard one to three days after treatment. Granular 2,4-D products are good to use in water bodies where drinking or irrigation water supply is of concern. While more effective in removing Eurasian watermilfoil, the liquid formulation of 2,4-D is much more persistent in the water. Water concentrations have been measured still above the drinking water standard for more than 30 days after treatment in a small lake.

A permit called a National Pollutant Discharge Elimination System Permit (NPDES) permit is needed to treat water bodies with aquatic herbicides.

Description of a milfoil eradication project in Washington using 2,4-D:

Lakes where 2,4-D is being used for milfoil eradication in Washington typically have milfoil scattered in patches within the littoral zone. The lake is surveyed immediately prior to herbicide application and milfoil locations are mapped and Global Positioning System (GPS) points established.

Herbicide application can begin as soon as milfoil starts rapidly growing. Effective treatments can be made as early as April or May and as late as early September or even October. Timing is also dependent on salmon usage since juvenile salmonids should not be exposed to certain herbicides. Under a court decision, the granular (ester) formulations of 2,4-D cannot be used in salmon-bearing waters. The amine formulation can be used in salmon-bearing waters, but its use is subject to fish timing windows. Treatment in the spring/summer should be followed by a late summer survey and possible retreatment if large patches remain or if more milfoil is discovered in untreated areas of the lake.

A month after the initial 2,4-D treatment, the littoral zone of the lake should be thoroughly inspected by divers to identify and map remaining milfoil plants. Sparse populations of remaining milfoil plants should be hand pulled or covered with bottom barrier. Larger, denser patches may need to be treated again with 2,4-D, although in that case some assessment should be made as to why the initial treatment was ineffective. Diver and surface inspections should continue at least twice a year during the growing season. Survey work should be as frequent as can be afforded since small milfoil plants may be easily overlooked within the native plant beds. Often divers report finding two to three foot tall milfoil plants in areas that they had extensively searched only three weeks earlier. Diving and visibility can be hampered in nutrient-enriched lakes with algae blooms or in tanin-stained waters.

Application of all aquatic herbicides in Washington must be made by a state-licensed applicator under an NPDES permit. The granular formulation of 2,4-D is typically applied using a bow-mounted centrifugal or blower-type spreader and the pellets are uniformly spread over the water above the milfoil beds and slightly beyond. The clay particles sink to the bottom or are caught up in the plants. The herbicide slowly releases from the clay and is taken up by the plants. Granular formulations are generally recommended for spot treatment since liquid applications may have more tendency to drift away from the milfoil beds. When the liquid formulation is used, it is applied using subsurface trailing hoses. In both cases, if the project is funded by an Ecology grant or if there are irrigation or drinking water concerns, monitoring will be required. A 2,4-D analysis test kit may be available soon or environmental laboratories can also perform 2,4-D analysis. Rapid turn around of results costs more.

General impacts of 2,4-D treatment:

2,4-D is a selective herbicide and Eurasian watermilfoil is particularly susceptible at a labeled rate of about 100 pounds per acre (granular product). If using the liquid formulation, an effective rate is 2 ppm (maximum label rate is 4 ppm). At these rates impacts to most other aquatic plant species are minimal. Even if applied at higher rates there are only a few other aquatic plant species that are affected by 2,4-D. A study conducted in Loon Lake Washington showed that Eurasian watermilfoil was the only aquatic plant whose growth was statistically reduced by the 2,4-D application (Parsons, et. al, 2001). In the Loon Lake study up to 98 percent of the Eurasian watermilfoil biomass in the treatment plots was removed after a July treatment.

A few days after the 2,4-D treatment, observers will see the growing tips of milfoil plants twist and look abnormal. These plants will sink to the sediments usually within one to two weeks of treatment. Unless treatment takes place in dense beds of milfoil, it is unlikely for low oxygen conditions to develop. Results of spot treatment may be variable depending on water movement, size of treatment plot, size of the water body, density of milfoil, weather conditions, underwater springs, etc.

Follow-up:

Follow-up is essential to ensure the success of eradication. Some plants survive the treatment and regrow (particularly when using the granular formulation of 2,4-D), so these plants must be removed by other means. Surveys done in Minnesota indicated that, 2,4-D use did not result in eradication of milfoil over the long-term (Crowell, 1999). Treated lakes for which there was no follow up survey work or treatment eventually ended up with milfoil throughout the littoral zone.

Eradication - Whole Lake Fluridone treatment

Fluridone (aquatic herbicide):

Fluridone is a systemic herbicide that kills the entire plant and is generally non-selective since most submersed plants will be killed or affected by a whole lake treatment. Fluridone inhibits the formation of carotene (pigment) in growing plants. In the absence of carotene, chlorophyll is degraded by sunlight. Because this is a slow process and the plants can “grow out” of this if fluridone is removed, the contact time between the plant and chemical needs to be maintained for many weeks. Sonar® and Avast!® are the trade names for aquatic herbicides that contain fluridone as the active ingredient. The liquid formulation of fluridone has been used for whole-lake milfoil eradication projects. New slow release granular formulations are also available, and are now being used for whole lake treatments. The premise for using fluridone as an eradication tool is that milfoil rarely produces viable seeds, so killing the vegetative growth will prevent spreading through fragmentation. Milfoil is particularly susceptible to fluridone and it is theoretically possible to achieve 100 percent kill. If <u>all</u> the milfoil plants are killed by fluridone treatment the only way that milfoil can reinfest the lake is to be reintroduced or germinate from seeds. Germination by seeds is considered rare.

Water bodies suitable for whole-lake fluridone treatment:

Lakes and ponds suitable for whole-lake fluridone treatment are heavily infested with Eurasian watermilfoil throughout the littoral zone. Fluridone is not suitable for spot treatments (sites less than five-acres within a larger waterbody) since it is difficult to maintain enough contact time between the plant and the herbicide to kill the plant. However, the newer granular formulations are slow-release and are beginning to be proved effective for treating smaller areas. If milfoil is limited to patches within the littoral zone, selective herbicides such as 2,4-D or triclopyr may be a more effective treatment method (see the 2,4-D milfoil eradication strategy). Due to the high treatment costs, fluridone treatments have been limited to smaller sites in Washington. The largest lake in Washington where this method has been used for milfoil eradication has been Long Lake (about 330 acres). In larger lakes, treatment of selected coves or embayments is possible, although milfoil will eventually reinvade from untreated areas.

Special considerations:

While there are no swimming, fishing, or drinking water restrictions when fluridone is in the water, the label warns against using the water for irrigation for seven to thirty days after treatment. Even at the low fluridone concentrations used to treat milfoil, some terrestrial plants may be sensitive to fluridone if they are watered with treated lake water.

Washington has had excellent success using this fluridone for milfoil eradication/control, but there is no guarantee that every lake group who tries this method will achieve the same results. Each site is different and many environmental factors may affect the treatment. Developing a site-specific plan for each lake is crucial to identifying environmental factors or concerns that may impact the treatment outcome.

Fluridone needs to be applied correctly and with an expert applicator to achieve the desired result. Because it is crucial to maintain a long contact time between fluridone and the targeted plants, designing a treatment plan and monitoring concentrations over time is an important part of each project.

A permit called a National Pollutant Discharge Elimination System Permit (NPDES) permit is needed to treat water bodies with aquatic herbicides. In Washington only state-licensed applicators may legally apply aquatic herbicides.

Description of a milfoil eradication project using fluridone:

When the project goal is eradication, a whole lake fluridone concentration of 8-10 ppb (parts per billion or μg/liter) should be maintained in the lake for approximately ten weeks during the spring and/or summer. While it is possible to achieve successful milfoil control at lower concentrations (as low as 3-6 ppb), these higher levels are recommended to ensure that all milfoil plants are killed.

Before application, the lake volume must be determined to ensure fluridone is applied in a sufficient amount to result in the target whole lake concentration. If the lake is shallow and not thermally stratified, concentrations throughout the water column must remain in the 8-10 ppb range. If the lake is deep and thermally stratified (warm above and cold below), these concentrations can be maintained in the epilimnion (warmer surface layer of water) rather than throughout the water column.

Treatment costs will vary based on lake surface area, water volume treated, and the number of treatments needed to maintain the target concentration for ten weeks. The SePRO Company (distributor for Sonar®) has developed a new patented test called planTEST™ that their preferred applicators may use. Treated plants are collected a few weeks prior to treatment and planTEST™ determines the concentration of Sonar® needed to kill the target weed. If milfoil in the lake is particularly susceptible to fluridone, it may be possible to reduce the concentration of fluridone needed to effectively treat the infestation.

Treatments can start as soon as milfoil begins rapidly growing. This can be as early as April or May and as late as early July and is site-specific. A critical factor particularly in western Washington is water flow. A heavy rainfall may wash the herbicide out of the system. For deeper lakes, treatment should be delayed until the thermocline develops and stabilizes in summer. For these reasons, fluridone treatments in Washington typically start in June or July rather than earlier.

Fluridone is applied in a liquid formulation by sub-surface injection from trailing hoses by a state-licensed applicator. About a day or two after treatment, water samples should be collected to determine fluridone concentrations. The number of samples required depends upon the size and shape of the lake. In a long narrow lake, three samples may be enough to determine lake concentration. In a small round lake, one sample taken in the middle may be sufficient. In a lake with many coves or channels, a number of samples may be needed to determine a whole lake concentration. Testing the water ensures that the target concentration of fluridone has been met. The SePRO Company has fluridone analysis test kits. Test results can be available within 48 hours and each sample costs about $100. Other laboratories can also perform fluridone analysis, but turn around times for results may be longer.

Fluridone concentrations are maintained in the lake over time by the application of additional herbicide at about bi-weekly intervals or as needed. To determine how much herbicide to add, water samples are collected about 10 to 14 days after the initial treatment and analyzed for fluridone. Generally during this two-week period, fluridone concentrations decrease by about half, due to plant uptake and exposure to sunlight. Fluridone is also more persistent in cooler waters. After fluridone concentrations are determined, the applicator applies enough herbicide to the lake to bring the whole lake concentration back up to the 8-10 ppb range. This scenario continues until fluridone concentrations have been held at 8-10 ppb in the lake for ten weeks. This fluridone concentration and exposure time should be sufficient to kill milfoil plants. During a typical treatment, the applicator may apply fluridone to the lake four times.

The SePRO Company has also developed a new patented test called effecTEST™ that their preferred applicators may use. Treated plants are collected at about five to six weeks after the initial treatment and effecTEST™ determines whether these plants have received enough herbicide to kill them or if a higher (or lower) concentration is needed.

General impacts of fluridone treatment:

There can be significant impacts to the water body during and following treatment. Fluridone is a generally non-selective herbicide, which means most submersed plants and some floating leaved plants will be killed by fluridone during the treatment. Emergent species like cattails will be impacted but will recover. A week to three weeks after the initial treatment, observers will see the growing tips of aquatic plants bleach pink to white. Water lilies will appear bleached and cattails and other emergent species may look variegated. Since this is a slow process, low oxygen conditions do not develop. The plants eventually drop out of the water column by about six weeks post-treatment.

While there is no direct toxicity of fluridone to animals, the loss of habitat does cause indirect impacts. The smaller fish lose their hiding places and because the larger fish can find them easily, they have greater chances of being eaten. Waterfowl that eat vegetation tend to move onto other vegetated waterbodies while waterfowl that eat fish enjoy better fishing opportunities on the treated lake. Sometimes increased algal blooms are observed in the year of treatment and for a year following treatment. However, eventually the lake reaches a new equilibrium and native aquatic plants recover. Naturally occurring plants have viable seeds, tubers, and overwintering buds that allow them to revegetate the lake the year following treatment, while milfoil does not. In Washington the colonization of the lake bottom by plant-like algae called brittlewort (*Nitella* spp.) and stonewort (*Chara* spp.) is often observed following a fluridone treatment. This is because algal species are resistant to fluridone and removing milfoil opens up space for them to colonize.

Up to 100 percent of the Eurasian watermilfoil in the lake should be killed. However in inlets or areas where the herbicide may be diluted by flowing water (including in-lake springs), milfoil may be under-treated and must be physically removed if eradication is to be successful. These areas should have been identified during plan development and alternative methods planned for milfoil removal. Under-treatment or no treatment of milfoil in inlet areas may result in the lake being reinfested unless immediate management methods are undertaken.

Follow-up:

For lakes that are heavily infested with milfoil, the goal of eradication should only be sought when sources are available to finance and conduct the follow-up monitoring and treatments that are essential to ensure long term success. The littoral zone of the lake should be thoroughly inspected by divers in the fall of the treatment year and the next spring as well to identify any milfoil plants that may have been under-treated. Areas where this might happen include areas of lake bottom with springs or near inlet streams. Any remaining milfoil plants should be hand pulled or covered with bottom barriers (See: Eradication - Hand Pulling and Bottom Barrier Installation). Diver and surface inspections should continue at least twice a year during the growing season on an ongoing basis. Survey work should be as frequent as can be afforded, since small milfoil plants may be easily overlooked. Often divers report finding two to three foot tall milfoil plants in areas that they had extensively searched only three weeks earlier. As native plants recover, it will become more difficult to locate any milfoil plants.

In most Washington lakes treated with fluridone, milfoil is found growing in the lake from two to five years later. It is suspected that milfoil is reintroduced via boating activity, since it is often discovered near a public boat launch. However, anecdotal evidence also suggests that milfoil seeds can germinate during dewatering. As long as the lake group has continued the survey work, these new introductions can be identified quickly and targeted for removal before milfoil reestablishes. In treated lakes where lake groups have continued the diver and surface inspections, milfoil remains at extremely low levels and recreation, fishing, and habitat remain healthy. A few lakes in Washington have achieved eradication. In the few lakes where inspections did not continue, milfoil reinvaded and the lakes returned to pre-treatment infestation levels.

Eradication Strategies – Hand Pulling and Bottom Barrier Installation

Hand Pulling:

During hand pulling, milfoil plants are manually removed from the lake bottom, with care taken to remove the entire root crown and to not create fragments. In deeper water, divers are usually needed to reach the plants.

Bottom Barrier Installation:

Bottom barriers are semi-permanent materials that are laid over the top of milfoil beds and are analogous to using landscape fabric to suppress the growth of weeds in yards.

Waterbodies suitable for handpulling and installation of bottom barriers:

Due to expense and the time intensive nature of manual methods, sites suitable for hand pulling and bottom screening are limited to lakes or ponds only lightly infested with Eurasian watermilfoil. This method is suitable for very early infestations of milfoil and for follow-up removal after a whole lake fluridone treatment, a 2,4-D treatment, or diver dredging. To be cost-effective, generally the total amount of milfoil in the waterbody should be three-acres or less in area, if all the milfoil plants were grouped together in one location. If the infestation has advanced beyond this point, it is more effective to consider other eradication techniques such as aquatic herbicides. This method may also be applicable in waterbodies where no herbicide use can be tolerated such as in a lake used as a municipal drinking water supply. Theoretically, these methods could be used in any waterbody to eradicate milfoil; however the costs for large scale projects would become astronomical.

Special Considerations:

Factors that affect the success of hand pulling include: water clarity, sediment type, suppression of milfoil fragments, density of native aquatic plants, and effort expended. It is especially important to have good visibility for the divers to locate milfoil plants. Sometimes diving is only effective in the spring or fall, or during periods between algal blooms. If water clarity is very poor, manual eradication methods may not be suitable for the waterbody. Hydraulic Project Approval is required for all hand pulling and bottom barrier projects. This permit is given in a pamphlet called Aquatic Plants and Fish and is available from the Washington Department of Fish and Wildlife.

Description of a milfoil eradication project in Washington using handpulling and bottom barriers:

Lakes where manual methods are being used for milfoil eradication typically have milfoil lightly scattered singly or in small patches within the littoral zone. To determine the extent of the infestation, the littoral zone of the lake is surveyed immediately prior to starting control work and milfoil locations are mapped and Global Positioning System (GPS) points established. The survey can be conducted prior to the removal effort or take place during the removal effort.

Hand pulling can begin as soon as milfoil can be easily seen and identified - generally in the spring or as soon as it is discovered in the lake. Despite milfoil's tendency to fragment more readily during the fall, removal should be undertaken as soon as possible after the discovery of milfoil in the lake, no matter how late in the season.

Survey Techniques

Both surface and underwater surveys should be conducted several times during the growing season. During the surface survey, a surveyor moves slowly through the littoral zone in a boat, looking into the water (often using a viewing tube), and marking the locations of milfoil plants with buoys. Surveyors advise wearing wide-brimmed hats, polarized sunglasses, and looking straight down into the water. Wind, rain, or surface disturbance, such as boat wakes, interferes with the ability to see. Morning to noon is often the most suitable time for survey work.

The surface survey is immediately followed by an underwater diver survey. Because known milfoil locations have been marked during the surface surveys, the divers can concentrate their efforts at these locations. Since diver time is expensive, it can be cost-effective to conduct surface surveys before underwater surveys.

Hand Pulling Techniques

During hand pulling, the divers dig around and beneath the plant roots with their hands or with a tool and gently lift the entire plant out of the sediment. The ease of removal is dependent on sediment type. Milfoil plants can be readily removed from loose or flocculent sediments. In hard sediments or rocky substrate, hand tools must be used to loosen the root crown before the plant can be dislodged. Sometimes fine roots are left behind; these will not regrow, but it is important to remove the root crown (the fleshy, fibrous roots at the base of the stem). Once plants are removed, the diver places them into bags for transportation to the surface. Sometimes divers may use a suction device to deliver the plant to the surface. The plant is sucked up into the boat (generally using a gold dredge), the plants are retained in a sieve, and the water is discharged back into the lake.

In locations with denser milfoil colonies, divers should make several passes through the area to ensure that all plants have been located and removed. As the divers work, the people in the support boat mark the locations of milfoil plants. An accurate location is important since the areas need to be resurveyed a few weeks later. There have been instances when small fragments or plants have been overlooked and have become large plants upon resurvey. Removed plants can be used for compost rather than having to be discarded as solid waste.

If colonies are too large for efficient hand pulling or if repeated visits to the same site indicate that too many fragments or plants are being missed, bottom barriers should be installed. Burlap bottom barrier (or other biodegradable material) should be placed over the plants and anchored to the lake bottom using natural materials such as rocks or sandbags. The burlap should cover and extend well beyond the growth zone of the plants. Burlap or other natural materials are preferred because they will naturally decompose over a 2-3 year period.

Some lake groups hire contract divers and surveyors to conduct manual plant removal activities. Other lakes have relied on volunteer efforts. If volunteers are used, they must be trained in plant identification and proper removal methods.

General Impacts of hand pulling

Special care must be taken to prevent the release of milfoil fragments. At certain times of the year (generally after flowering), milfoil plants can fracture into hundreds of fragments, each having the potential to form a new plant. To help contain the fragments, individual plants may be covered with a mesh bag before they are pulled. The driver of the diver support boat must also be careful not to create additional fragments by keeping the boat and propeller out of the milfoil plants. People in the support boat should use net skimmers to retrieve any fragments accidentally released by the divers.

Hand pulling may increase turbidity in the area of removal. This can affect the efficacy of removal if the turbidity interferes with the ability of the divers to see the milfoil plants.

Follow-up:

Follow-up is essential to ensure the success of eradication. Even a few milfoil fragments left in the lake can start a new infestation or boaters may reintroduce milfoil into the lake. Diver and surface inspections should continue at least twice a year during the growing season. Survey work should be as frequent as can be afforded since small milfoil plants or fragments may be easily overlooked.

Control/Eradication – Diver Dredging

Diver Dredging:

Diver dredging is a mechanical control technology for milfoil removal that was pioneered by the British Columbia Ministry of Environment. During diver dredging operations, divers use venturi pump systems (small gold mining dredges) to suction plants and roots from the sediment. The pumps are mounted on barges or pontoon boats and the diver uses a long hose with a cutter head to remove the plants. The plants are vacuumed through the hose to the support vessel where the plants are retained in a basket and sediment and water are discharged to the waterbody. Often a silt curtain is deployed around the treatment site to control turbidity.

Waterbodies suitable for diver dredging:

Sites suitable for diver dredging include lakes or ponds lightly to moderately infested with milfoil. Because diver dredging can be very expensive, this method is most suitable for moderate to early infestations of milfoil and for follow-up milfoil removal after an herbicide treatment. Diver hand pulling is more effective in lightly scattered patches of milfoil, whereas diver dredging may be more appropriate in denser milfoil beds. Diver dredging may also be applicable in waterbodies where no herbicide use can be tolerated. Theoretically diver dredging could be used in any waterbody to eradicate milfoil; however the costs for large scale projects would become astronomical.

Special Considerations:

Development of an integrated vegetation management plan is advised prior to beginning a diver dredging project. Diver dredging projects may require a federal permit from the US Army Corps of Engineers. The necessity for the Corps of Engineers permit is site dependent. State permits for diver dredging for noxious weed removal is covered by the Hydraulic Approval pamphlet Aquatic Plants and Fish.

Description of a diver dredging project in Washington:

The littoral zone of the lake is surveyed immediately prior to starting control work and milfoil locations are mapped and Global Positioning System (GPS) points established.

Diver dredging can begin as soon as milfoil can be easily seen and identified - generally in the spring. If diver dredging is being used as a milfoil eradication method also see the milfoil eradication strategy using hand pulling and bottom barrier installation. Diver dredging can be used in conjunction with these other methods to achieve eradication; with dredging used to reduce the density of plants, followed up by hand pulling. Generally diver dredging projects continue for several years and are very expensive.

During diver dredging, the divers may use a tool to loosen milfoil root crowns before using a suction head to remove the plant. In hard-packed or rocky sediments, the plants often break off at the root crown, leaving the root behind to regrow. In these areas, alternative control methods, such as bottom barrier installation, should be used. In locations with denser milfoil colonies, divers should make several passes through the area to ensure that all plants have been located and removed. Removed plants can be used for compost rather than having to be discarded as solid waste.

Factors that affect the success of diver dredging include: sediment type, visibility, amount of fragments created, density of native aquatic plants, and effort expended. The amount of acres covered per day is dependent on plant density, ease of removal, and number of divers. Once milfoil plants have become sparse, diver hand pulling is just as fast as dredging and has less impacts.

Sometimes diver dredging equipment is used just to transport plants to the surface. The diver pulls the plant and uses the dredge hose to suction the plant to the support boat rather than placing the plants in a bag and carrying them to the surface. Using a dredge for plant disposal is not considered dredging and does not trigger the need for Corps of Engineers approval.

In Washington, diver dredging was used in Silver Lake in Everett to contain a relatively early infestation of milfoil. Although milfoil was not eradicated in Silver Lake, dredging, in combination with hand pulling and bottom barrier installation, did remove most of the milfoil from the lake. Diver dredging is also being used in Idaho lakes and rivers to contain recently discovered milfoil populations.

General impacts of diver dredging:

No research has been conducted in Washington to quantify the impacts of diver dredging. Although the object of diver dredging is to remove milfoil, sediment is unavoidably stirred into the water. The obvious impact of diver dredging is increased turbidity in the area of plant removal with the degree of turbidity dependent on the sediment type. Fine silty sediments produce more turbidity than sandy or rocky sediments. If turbidity interferes with the ability of the divers to see the milfoil plants, efficacy of plant removal can be affected. Diver dredging may also release buried pollutants and/or nutrients. In Silver Lake, sediment bioassays were required prior to dredging to ensure that the sediments did not contain toxic materials. Bioassays are probably more important in waterbodies with a history of mining, combined sewage outfalls, land filling, storm water outfalls, or other activities that may have contributed pollutants to the sediments.

It is very difficult to control fragment release during dredging operations. If a silt barrier is deployed around the dredging site for turbidity control, divers should make an attempt to collect milfoil fragments within the area before removing the barrier.

Follow-up:

Diver dredging, used alone, is probably not an eradication tool, but it can be the first step to reducing the biomass of milfoil to the point where other manual methods can be used to eventually eradicate the plant.

Control - Mechanical Harvesting

Harvesting:

Harvesting is a way to mechanically remove milfoil in order to provide open areas of water for recreational activities and navigation. Harvesting immediately removes surfacing milfoil mats, but since the cut plants grow back (sometimes within weeks), the same area may need to be harvested twice or more per growing season. Harvesting machines (harvesters) are specialized underwater mowing machines specifically designed to cut and collect aquatic plants. Cut plants are immediately removed from the water via a conveyer belt. The cut plants are stored on the machine until they can be off-loaded and disposed of properly. Several manufacturers sell various sizes and models of machine, and there are firms that contract for harvesting operations.

Waterbodies suitable for harvesting programs:

Waterbodies suitable for harvesting programs include larger lakes (about 100 acres or more), and rivers with widespread, well-established milfoil populations, where milfoil eradication is not an option. Since on-going harvesting operations are expensive, having a large lake association, residential community, or a motivated local government to share the harvesting costs is crucial.

Special considerations:

Harvesting is not recommended in waterbodies with early infestations of milfoil since the resulting fragments are never completely contained and harvesting may increase the spread of milfoil throughout the waterbody. Because harvesting is a whole-lake activity it should be conducted under the direction of an integrated aquatic vegetation management lake plan. Factors to consider when designing a harvesting program include:

- Lake surface area, width, and depth;
- Vegetated acres;
- Bottom contours and bottom obstructions such as stumps, rocks, other debris;
- Traffic patterns,
- Prevailing winds;
- Harvester launching and off-loading sites;
- Shoreline development; and
- Sensitive areas (critical habitat).

A reliable funding source, such as a Lake Management District or a committed local government, is necessary to provide funding either to purchase and operate a harvester or to contract for harvesting on an annual basis. In at least one jurisdiction (Skagit County, Washington), the County trained volunteers to operate the County-owned harvester to remove milfoil on local lakes. However, liability may become an issue with volunteers using harvesters since harvesting machines have been known to capsize when improperly filled or overloaded.

A lake committee and/or local government staff identifies acreages and areas to be harvested within the lake. Priorities may be determined by who funds the program. For example, a local government will be more interested in harvesting public areas, whereas the lake group may be interested in harvesting the areas in front their homes. In general, high use areas such as public parks, community access points, navigation channels, public boat launches, and water ski lanes receive priority for clearing. Because harvesters are large machines and are difficult to maneuver near-shore between and around docks, in at least one harvesting program (Long Lake, Thurston County), harvesting was limited to areas outside of the docks. Individual homeowners, at their discretion, were considered responsible for removing plants growing between the end of the dock and their shoreline.

Prior to harvesting, machinery launch sites (a paved ramp with deep water is best), and plant disposal off-loading sites need to be identified. A summer harvesting schedule must be developed. If harvesting services are contracted, bid documents and a contract need to be prepared. Hydraulic Project Approval must be obtained from Washington Fish and Wildlife.

Description of a harvesting project:

Harvesting starts when plants have neared or approached the water surface. The harvester's cutting head is lowered into the water and the harvester moves forward, cutting and collecting plants as it advances. Harvesters vary in size and capability. Most cut plants about five feet below the water and in a swath between five and ten feet wide. Bigger, faster machines with larger cutting heads and holding capacities may be more efficient, but are also less maneuverable. Depending on time of year, weather, and depth of cut, the same area may need to be harvested again in a few weeks.

The cuttings are collected on a conveyer belt and deposited in a holding area on board. Although the harvester collects most plant materials as it operates, inevitably some fragments are missed. Not overloading the carrying capacity of the harvester helps to keep plant fragments to a minimum. Along with plants, the harvester also inadvertently collects small fish (some are able to escape from the conveyer belt) and invertebrates.

When the plant storage area is filled, the harvester must off-load the cut plants. Plants can be off-loaded to either a barge stationed offshore or to a trailer or dump truck. These plants may be used as compost or disposed of in a land fill. As the distance from the work area to the off-loading site increases, the time spent on plant disposal activities can exceed the time spent cutting. This can add greatly to the duration and expense of the project and is a critical limitation to some harvesting projects. The plant density and machine specifications will also determine how often the harvester needs to off-load the cut plants.

Delays in the harvesting schedule can result from high winds, thunderstorms, and mechanical failure. Unscheduled maintenance or machine breakdowns can also result in lost harvesting time.

Complaints about harvesting have included reports by homeowners that plant fragments wash up more frequently on their beaches after harvesting. Homeowners may also report that their neighbor's property was harvested sooner or the job done more thoroughly than at their own property. It is important to establish some clear guidelines and policies to help make decisions and to settle disputes.

General impacts of harvesting:

While some people view harvesting as an excellent non-chemical control method for milfoil, others scoff at the waste of money to "merely mow the weeds." Harvesting plants has the added benefit of removing nutrients from the waterbody that are tied up in the plant biomass. Because only the top part of the plant is removed, the rest of the plants remain for habitat and sediment stabilization.

Harvesters are large machines and occasionally hydraulic fluid or fuel are leaked or spilled. The operator should have a spill plan and containment equipment available at all times. When working in shallow water, the propulsion system or the cutter head can sometimes churn up the sediment creating turbid water. Significant numbers of fish can be removed from a waterbody during harvesting activities as fish become collected along with the cut plants (Mikol, 1985). These are often juvenile fish, because larger fish can more easily avoid the harvester. Long term milfoil harvesting programs in Washington state include; the Columbia River, Lake Washington, and Green Lake. There is also a program aimed at native plant control on Long Lake (Thurston County).

Control - Rotovation (underwater rototilling)

Rotovation:

A rotovator is a barge-mounted rototilling machine that lowers a tiller head about eight to ten inches into the sediment to dislodge milfoil root crowns. The mechanical agitation produced by the tiller blades dislodges the root crowns from the sediment and the buoyant root masses float to the water surface. Since the entire plant is removed, plant biomass remains reduced in the treatment area throughout the growing season and often longer. Rotovation often provides two full seasons of control (Gibbons et. al, 1987). Unlike harvesters, rotovators do not have the capability to collect the plants

Waterbodies suitable for rotovation programs:

Rotovation is a way to mechanically remove milfoil to provide open areas of water for recreational activities and navigation. Waterbodies suitable for rotovation include larger lakes or rivers with widespread, well-established milfoil populations where milfoil eradication is not an option. Since on-going rotovation programs are very expensive, having a large lake population or a motivated local government to share these costs is crucial. Because rotovation is expensive and multiple permits are needed, rotovation has not become a wide-spread milfoil control activity in Washington or elsewhere in the United States.

Special considerations:

Rotovation is not recommended in waterbodies with early infestations of milfoil since fragments are created and rotovation may increase the spread of milfoil throughout the waterbody. Because rotovation creates turbidity, rotovation may not be appropriate in salmon-bearing waters, although sometimes Fish and Wildlife staff are able to provide windows of time when rotovation activities will have the least impact on fish. Because rotovation and the resultant turbidity may impact the entire waterbody, it should be conducted under the direction of an integrated aquatic vegetation management plan. Rotovation requires Hydraulic Project Approval from Fish and Wildlife.

Factors to consider when designing a rotovation program include:

- Waterbody surface area, width, and depth;
- Vegetated acres;
- Bottom contours and bottom obstructions such as stumps, rocks, other debris;
- Traffic patterns,
- Prevailing winds;
- Rotovator launching and off-loading sites;
- Sediment type;
- Shoreline development; and
- Sensitive areas (critical habitat).

A waterbody committee and/or local government staff identifies acreages and areas to be rotovated. Priorities may be determined by who funds the program. A local government will be more interested in rotovating public areas, whereas local residents may be interested in rotovating areas in front their homes. However, generally high use areas such as public parks, community access points, navigation channels, public boat launches, and water ski lanes receive priority. Sometimes rotovators can be used to create fishing lanes in dense beds of milfoil to provide better fishing access to anglers.

Prior to rotovation, machinery launch sites (a paved ramp with deep water is best) need to be identified. Since rotovators do not collect plants as they work, a method for removing plants from the water should be developed. This may involve having a harvesting machine follow behind the rotovator to collect plants or hiring people to rake plants off beaches. When Pend Oreille County rotovates milfoil in the Pend Oreille River, they begin at the milfoil bed furthest upstream. The plants are then carried downstream and get caught up on the remaining dense milfoil beds. Their rotovator also has a clam rake attachment that can be used to pick up the plants and place them on-shore. This removal technique is acceptable on the Pend Oreille because there are many uninhabited shoreline areas. This would not be suitable in well-populated bodies of water.

Description of a rotovation project:

During a rotovation project, the rotovator tilling head is lowered into the sediment and power is applied. The rotating head churns into the sediment dislodging milfoil root crowns and plants, and a plume of sediments. The rotovated plants eventually sink or wash up on shore and the sediments gradually settle from the water. Canadian plant managers have recorded milfoil stem density and root crown reductions of better than 99 percent after rotovation test trials (British Columbia Ministry of Environment memo dated 1991). Where repeated treatments have occurred at the same site over several consecutive years, treatment intervals may extend longer than two years (Gibbons, et. al, 1987).

If rotovation services are contracted, bid documents and a contract need to be prepared, but there are few, if any, contractors offering these services. In a few waterbodies such as in the Pend Oreille River, rotovation may be performed year-round. In most waterbodies, timing is dependent on fish windows. Washington Fish and Wildlife does not want rotovation activities to take place when fish are spawning or juvenile salmon are migrating through the waterbody.

For efficacy of milfoil removal, it's best to begin operations in early spring and resume again in the fall. Rotovation is less effective in the summer when the long milfoil plants wrap around the rotovating head, slowing down the operation. If rotovation is done during the summer, it is more efficient to cut or harvest the plants beforehand. Weather creates winter rotovation delays, although it is possible to rotovate throughout the winter months (as long as the waterbody doesn't freeze). Delays in the rotovation schedule can result from high winds, thunderstorms, freezing water, and mechanical failure. There is a lot of maintenance and some down time on machinery working on the water.

Complaints about rotovation include increased plant fragments washing up along shorelines, broken water intakes, and homeowners perceiving that their neighbor's property was rotovated sooner or more thoroughly than their own property. It is important to establish some clear guidelines and policies to help make decisions and to settle disputes.

General impacts of rotovation:

Rotovators stir sediments into the water column. In addition to the sediments, buried toxic materials and/or nutrients may be released. Generally turbidity is short-term and the water returns to normal within 24 hours, but the length of time that sediments remain suspended depends on sediment type. Plants and root crowns are uprooted from the sediment and unless a plant removal plan is in place, these plants will either sink or be washed on shore. Rotovation appears to stimulate the growth of native aquatic plants. Whether this is due to the removal of milfoil, the action of the rotovator stimulating seed or propagule germination, or a combination of these factors is not known. Rotovators are also large machines with hydraulic systems and fuel that occasionally leaks or is spilled. The operator should have a spill plan and containment equipment on board for emergency use.

In 1987, Ecology conducted an evaluation of rotovation in Lake Osoyoos. This lake was chosen because it has a history of mining and agricultural use and therefore might represent a "worst case" scenario in terms of the potential for release of contaminants from sediment. The objectives of the study were to document effectiveness of rotovation by measuring changes in milfoil stem densities before and after treatment, and to assess impacts of rotovation on selected water quality parameters, benthic invertebrates, and the fisheries. Although the rotovator malfunctioned during the test (the hydraulic system driving the rototiller was not functioning properly), the results were consistent with data collected by the British Columbia Ministry of the Environment of sites rotovated by a fully operating rotovator. During the Lake Osoyoos rotovator test, rotovation appeared to have little impact on fish, water quality, or benthic invertebrates. However during this test, milfoil stem densities were not reduced to the extent that should have occurred had the machinery been operating properly. Although the results indicated only short-term impacts associated with rotovation, the test was faulty and it is difficult to draw firm conclusions. This study was not repeated using a fully functioning machine

Control – Biological (milfoil weevil)

Mattoon Lake was selected as a milfoil weevil introduction site in 2002 as a special project through the Department of Ecology. The milfoil weevil (*Euhrychiopsis lecontei*) (a beetle in the family Curculionidae) has been implicated in causing declines of Eurasian milfoil in Midwestern and Northeastern States. This weevil is native to the northern part of the United States, including Washington (Tamayo and Grue 1996). The weevil's native host is the native northern milfoil (*Myriophyllum sibiricum*), however, if the weevil is reared on Eurasian milfoil it will prefer it over northern milfoil. The weevils spend their entire life cycle on milfoil. The adults eat leaves on the growing tips, and larvae mine into the stem causing a reduction in plant buoyancy.

Through the summer of 2002 adult weevils were collected from Stan Coffin Lake in Grant County each week for about 12 weeks by snorkeling (once from near-by Burke Lake). A total of 705 adult weevils were collected from *M. sibiricum* (northern milfoil) plants. The peak collection time was the end of July through the end of August, when an experienced snorkeler could collect at a rate of about one weevil per minute. Often there were two or three weevils per milfoil stem, a density thought to be great enough to control *M. spicatum* growth (and, in fact, Eurasian milfoil is present in Stan Coffin lake, but difficult to find).

The captured weevils were kept in aquariums at the Fish and Wildlife Department buildings in Yakima for between 5 and 14 days. At the end of the rearing period the numbers of eggs, larvae, and adults were counted and then the weevils and their progeny were introduced into Mattoon Lake at designated release sites. This cycle of rearing and release continued throughout the summer, and by the end of summer a total of nearly 3,000 weevils of all life stages had been released.

To monitor the milfoil weevil population at Mattoon Lake, two methods were used: a qualitative check for weevil damage on milfoil plants, and quantitative sampling at points throughout the lake. Prior to the initial introduction of milfoil weevils, Mattoon Lake was inspected for an existing weevil population. The lake was checked again using the same methods in early September of 2002 toward the end of the stocking period. For the qualitative check for weevil damage, experienced weevil-hunting snorkelers conducted three 20-minute visual searches in selected areas of the lake, including those sites chosen for weevil introduction. No signs of weevils or weevil damage were observed during either of the inventories in 2002 and there was no sign of weevil establishment in Mattoon Lake at the end of 2002. In conjunction with this project, the Department of Fish and Wildlife had conducted a fish population inventory of Mattoon Lake in spring 2002. That inventory revealed that Mattoon Lake has a very dense population of small pumpkinseed sunfish (Divens 2003). Other studies have found that pumpkinseed and bluegill sunfish will eat milfoil weevil adults (Sutter and Newman 1977; Lord et al 2003). Thus, it was suspected that the pumpkinseed in Mattoon Lake ate the weevils that were being introduced.

In 2003 a fish exclosure cage was set up to try to address the fish predation issue. A 10 ft x 10 ft exclosure frame was constructed and surrounded with fish netting suspended by floats at the top and held in place with weights at the bottom to keep fish out of the study area. Fish traps were also set and angled to catch any fish that were caught inside the exclosure.

Over the course of the summer 2003 a total of 1,670 weevils we collected, raised and released of all life stages into the enclosure, and another 815 outside the enclosure at the southwest end of the lake by tying milfoil fragments with weevils onto rooted milfoil. Adult weevils were observed in the enclosure from previous releases toward summer's end, but the population never established enough to control the milfoil. At the end of summer (September 24, 2003) the enclosure was removed and in the summer of 2004 it was snorkeled where the enclosure had been located. A few adult weevils were found in the area, however, they did not seem to persist or establish in numbers great enough to control the milfoil. The Department of Ecology was encouraged to find that weevils did survive in Mattoon Lake, but were disappointed they did not establish as of the summer of 2004 and the project was concluded. They hope to continue research into the fish predation issue in future years.

Integrated Treatment Plan

Mattoon Lake and its associated shoreline contains three listed noxious weed species that should have control measures implemented to halt the spread of their invasions and reverse the degradation currently occurring. The three target species are Eurasian watermilfoil (*Myriophyllum spicatum*), purple loosestrife (*Lythrum salicaria*), and yellow flag iris (*Iris pseudacorus*). Although all three species at Mattoon Lake are highly aggressive and are difficult to control/eradicate, we believe that the goal of eradication is reasonable for all of them, and we can be successful within the time frame of the project.

Eurasian watermilfoil (*Myriophyllum spicatum*)

Control and management of Eurasian watermilfoil will be accomplished using an aquatic formulation of 2,4-D (DMA*4IVM®, AquaKleen®, or Navigate®) in late May to early June of 2008, depending on growth stage. Treatment areas will designated according to the annual survey results. Although the committee favors the use of 2,4-D as the primary herbicide, other alternatives should be researched and considered as new technologies become available. Annual surface and/or dive surveys will be conducted over the entire lake to check the status of the infestation, and treatment sites will be mapped with a GPS. When a treatment is near, the areas will be marked on the water's surface with buoys and then the application will performed by a licensed applicator via a boat to disperse the herbicide. Of the three available 2,4-D formulations, DMA*4IVM® is preferred based on literature indicating that 100% control is achievable with amine formulations. Follow-up applications may occur about three weeks after the initial treatment to pick up missed plants or late emergents. Diver hand-pulling may be necessary to clean up any remaining milfoil found after herbicide applications have had time to take effect or in areas that are not feasible for a chemical treatment. Surface and/or dive surveys after the initial application shall include a post evaluation of the site. This evaluation shall include an estimate of the effectiveness of the application (qualitative or quantitative), any dead or dying organisms or plants, algae conditions, and any other environmental data which may be available (dissolved oxygen, pH, Secchi disk, turbidity, etc.). Survey evaluations are essential to determining the success of the effort, and will be used to determine what measures need to be implemented to improve milfoil control. Because of the environmental risks from improper application, aquatic herbicide use in Washington State waters is regulated by the National Pollutant Discharge Elimination System (NPDES) permit. All specific protocols of the NPDES permit coverage from Washington State Department of Agriculture (WSDA) will be directly followed in Mattoon Lake by the licensed applicator and the involved committee. If all specific protocols of the NPDES permit are followed, it should be relatively simple for the control applicator to avoid collateral damage and preserve the plant community of the lake. If it is discovered that the plants are less susceptible to 2,4-D than expected, then it may be necessary to shift from 2,4-D to triclopyr. The aquatic formulation of triclopyr is registered and sold as Renovate 3®. Triclopyr is similar to 2,4-D in its mode of action (systemic) and selectivity. Although eradication of Eurasian watermilfoil is the end goal, 100 percent control may not be feasible without becoming cost prohibitive. Eurasian watermilfoil should be drastically reduced, but may not be eliminated, by this integrated approach, however, herbicide applications, followed by manual methods, should ensure proper Eurasian watermilfoil control.

The NPDES permit coverage from WSDA requires notification and posting of the waterbody, and these specific protocols will be followed. The NPDES permit also requires monitoring of the herbicide levels in the lake after treatment. Independent samples will be collected at the time of the application and again five days post treatment.

A follow-up application in Year 1, about three weeks after the first treatment, will aim to pick up missed plants or late emergents. We will plan on a maximum of 25% of the original area of 8 acres to need the follow up. It may be necessary to utilize diver hand-pulling to clean up any remaining milfoil found after both herbicide applications have had time to take effect (i.e. two to three weeks after the second herbicide treatment).

A bottom barrier will be installed at the boat launch in the winter of Year 1 to ensure eradication in the vicinity, and to aid in preventing new introductions. Community education efforts will continue, including an increase in the signage at the boat launch and surrounding high-traffic areas.

Year 2 will begin with surveys of the lake to check the status of the infestation. Spot herbicide treatments will begin in late May to early June based on survey results over an estimated maximum of 50% of the original milfoil infested area. A follow-up application, about three weeks after the first treatment, will aim to pick up missed plants or late emergents. We will plan on a maximum of 25% of the original area of 8 acres to need the follow up. Diver handpulling may be implemented about three to four weeks after the herbicide treatment. At this point, we expect to see a 90% or greater reduction in the size of the original Eurasian watermilfoil infestation. Annual maintenance of the bottom barrier at the boat launch may require removal of rooted plants and sediment accumulations, as well as securing the barrier to the bottom to ensure safety and effectiveness. Continued community education will complete our Eurasian watermilfoil efforts for Year 2.

In Years 3-5 (and beyond), surveys will occur at least twice during the growing season. Manual and/or chemical controls may be performed as needed and necessary permits acquired. Continued maintenance of the bottom barrier will be implemented as needed. Eurasian watermilfoil should be eliminated by this outlined integrated approach. Two herbicide applications per season in the first year(s), followed by any needed manual methods, should ensure that no milfoil plants survive. Once the established plants are eradicated, and follow up surveys have verified their absence for several seasons, potential reintroduction will be a remaining challenge. Annual surveys are essential in determining if, when, and where reintroduction has occurred. In the event that a new infestation is identified, rapid response will be critical in preventing re-establishment.

There should be no need to revegetate the areas of Eurasian watermilfoil after treatment. Most of the native submersed species are monocots that should be relatively unaffected by the 2,4-D application. Removing the noxious invaders will halt the degradation of the system and allow the dynamic natural equilibrium to be maintained.

Purple loosestrife (*Lythrum salicaria)*

Control efforts on purple loosestrife will be carried out and continued by the Kittitas County Noxious Weed Control Board with complete eradication as the goal.

Surveys (at least 2) will be performed annually and any loosestrife found will either be spot treated with an aquatic herbicide (triclopyr or imazapyr) or mechanically removed, depending on site conditions and plant phenology. Treated plants will be checked 1 month after control. If flowering stalks are found they will be cut at the base and disposed of as garbage. Since purple loosestrife grows mainly along the shoreline in wetland areas where rapid re-colonization by native plants should occur after treatment, there should be no need to revegetate.

Yellow flag iris (*Iris pseudacorus)*

Control efforts on yellow flag iris will be implemented on the shoreline of Mattoon Lake with the goal of eventual eradication. Spot applications of an aquatic formulation of imazapyr (Habitat™ or Polaris™) are planned for Years 1-5 as needed. Plants will be checked 1 month after herbicide application, and any that have produced flowers will be manually controlled before they set seed. These plants will be cut at the base and disposed of as garbage. Since yellow flag iris grows mainly along the shoreline in wetland areas where rapid re-colonization by native plants should occur after treatment, there should be no need to revegetate.

Additional control efforts will be accomplished through educational outreach.

Curly leaf pondweed (*Potamogeton crispus)*

It is not expected that curly leaf pondweed will be specifically targeted for control. Unlike milfoil, curly leaf pondweed usually will die back in the summer months in response to increasing water temperatures and rarely is a problem in Washington State. . Monitoring of its density and distribution will continue indefinitely.

Plan Elements, Costs, and Funding

Table 2 outlines the tasks and estimated costs of implementation on an annual basis. Implementation of the Mattoon Lake IAVMP will span at least 5 years, at a total estimated cost of $32,400. The majority of the costs accrue in the first two years, which is the period of most aggressive treatment. Beyond that, costs are directed at detecting and controlling re-introduction of noxious aquatic plant species.

Table 2. Mattoon Lake Project Budget

Task	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Surveys	$750	$750	$750	$750	$750	$3750
Herbicide - milfoil	$6200	$3600				$9800
Herbicide - yellow flag iris	$900	$900	$300	$300	$300	$2700
Post treatment monitoring	$750	$750	$250	$250	$250	$2250
Diver handpulling	$4000	$4000				$8000
Bottom barrier	$2000	$200	$200	$200	$200	$2800
Education & outreach	$500	$500	$500	$250	$250	$2000
Printing costs	$500	$200	$200	$100	$100	$1100
Total Costs	Year 1 $15,600	Year 2 $10,900	Year 3 $2200	Year 4 $1850	Year 5 $1850	Total $32,400

Funding

The Washington State Department of Ecology has an Aquatic Weeds Management Fund to tackle the problem of aquatic weeds on a statewide level. In 1991, the legislature established the Freshwater Aquatic Weeds Account to provide financial and technical support to tackle the problem on a statewide level. This Account provides funding for technical assistance, public education and grants to help control aquatic weeds. Revenue for the Account comes from a $3 increase in annual license fees for boat trailers. Grant projects must address prevention and/or control of freshwater, invasive, non-native aquatic plants. The types of activities funded include: Planning, education, monitoring, implementation, pilot/demonstration projects, surveillance and mapping projects. Grant applications are accepted from October 1 through November 1 of each year during a formal application process. Grant applications are evaluated by people experienced with aquatic plant management. Funds are offered to selected applicants in the winter. Generally about $300,000 is available during each annual funding cycle. An additional $100,000 is available on a year-round basis for "early infestation" grants. The purpose of early infestation grants is to provide immediate financial assistance to local or state governments to eradicate or contain an invasion of a non-native aquatic plant. Funds are limited to $30,000 (state share) for planning grants and $75,000 (state share) for other projects. Each public body is limited to $75,000 per annual grant cycle and $75,000 for "early infestation". Early infestation projects are limited to $50,000 per project. Local sponsors are required to provide 25 percent of the eligible project costs as a match to state funds. However, in-kind services can be used for up to one-half of the local share. Grants of up to 87.5 percent of the eligible project costs can be provided for "early infestation" projects and for pilot projects. Projects dealing with the prevention or management of freshwater invasive submersed plants like Eurasian watermilfoil or Brazilian elodea receive funding priority over projects dealing with nuisance native plants. Projects that implement an approved integrated aquatic plant management plan receive the highest priority. Other factors considered when evaluating projects include the environmental and economic impacts of the problem plants on the ecosystem, the degree that the project will benefit the public, the likelihood of the problem plant to spread to other waterbodies, the long-term interest and commitment to the project by the waterbody residents, and state wide significance of the project.

This IAVMP was developed to be consistent with all AWMF guidelines and requirements. Given the relatively limited distribution of milfoil in Kittitas County, the outstanding recreational and ecological value of Mattoon Lake, and the potential for infestation of neighboring lakes, it is hoped that Ecology will offer funding. Other possible grant monies are available and will be researched.

The Kittitas County Noxious Weed Control Board has limited funds available to contribute to weed control projects. While this shouldn't be considered a source of funding, their volunteer efforts are promised to the project and their office will implement the needed surveys and control strategies necessary for purple loosestrife eradication at Mattoon Lake.

The Kittitas Field and Stream Club has limited funds available to contribute to projects that benefit recreational opportunities within Kittitas County. While this can not be considered an ongoing source of funding, they have expressed interest in possibly contributing to the project.

References

Anderson, Eric 2006 – 2007. Personal communication. District Fish Biologist. Washington Department of Fish and Wildlife. Ellensburg, WA.

Gibbons, M.V., H.L. Gibbons, Jr., and M.D. Sytsma. 1994. *A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans*. First Edition. Washington State Department of Ecology, Olympia, WA.

King County Department of Natural Resources and Parks. Water and Land Resources Division . 2003. *Spring Lake Integrated Aquatic Vegetation Management Plan*. Washington State Department of Ecology Aquatic Plant Management Website: http://www.ecy.wa.gov/programs/wq/plants/management

Liberty Lake Sewer and Water District. 2004. *Liberty Lake Aquatic Vegetation Management Plan*. Washington State Department of Ecology Aquatic Plant Management Website: http://www.ecy.wa.gov/programs/wq/plants/management

Parsons, Jenifer. 2006 - 2007. Personal communication. Aquatic Plant Specialist. Aquatic Weeds Management Program. Washington Department of Ecology. Yakima, WA

Washington State Department of Ecology, 2007. *Aquatic Plant Monitoring. Mattoon Lake Report.* Retrieved March, 2007. Available online at: http://www.ecy.wa.gov/apps/watersheds/aquaticplants/lakereport.asp?id=502

Washington State Department of Ecology, 2007. *Aquatic Plant Management website.* Retrieved March, 2007. Available online at: http://www.ecy.wa.gov/programs/wq/plants/management

Washington Department of Fish and Wildlife, 2007. *Fish Plants and Stocking Reports*. Available online at: http://wdfw.wa.gov/fish/plants

Washington State Noxious Weed Control Board. 2006. *Eurasian watermilfoil.* In: Written Findings. Available online at: http://www.nwcb.wa.gov/weed_info/Myriophyllum_spicatum.html

Washington State Noxious Weed Control Board. 2006. *Purple loosestrife.* In: Written Findings. Available online at: http://www.nwcb.wa.gov/weed_info/Lythrum_salicaria.html

Washington State Noxious Weed Control Board. 2006. *Yellow flag iris.* In: Written Findings. Available online at: http://www.nwcb.wa.gov/weed_info/Iris_pseudacorus.html